DEPARTMENT OF EMPLOYMENT AND PRODUCTIVITY

Safety in the Use of Press Brakes

Seventh Report of the Joint Standing Committee on Safety in the Use of Power Presses

LONDON
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Contents

	Page
Members of the Committee	V
Members of the Press Brake Sub-Committee	VI
Letters of Presentation	1

Part I Designing Press Brakes for Safety

	Para.	Page
General	1.1	6
Items needing special attention	1.2	6
	1.3	6
Clutch and brake operating linkages – new machines	1.4	6
Clutch and brake operating linkages – existing machines	1.5	6
Friction clutch design	1.6	7
Limitations of hand brakes – improvements and alterations	1.7	7
Fitting of single-stroke devices	1.8	8
Cam adjustment on single-stroke devices and detection of overrun	1.9	8
Device to prevent overrun – provision of positive stops	1.10	9
Device to prevent overrun – provision of arrestor brakes	1.11	9
Recommendations in respect of overrun protection devices	1.12	9
Reduction of inertia of moving parts	1.13	10
Development of press brakes with air-operated clutches (friction)	1.14	10
Control of air-operated friction clutch presses	1.15	11
Prevention of gravity fall-back and fall-forward of the beam	1.16	11
Hydraulic press brakes	1.17	11
Precautions with pedals and treadles	1.18	11
Summary of main recommendations for machine design for safety		12

Part II Safeguarding of Press Brakes

	Para.	Page
Basic guarding methods in use	2.1	16
Fixed guards	2.2	16
Automatic guards	2.3	16
	2.4	16
Trip guards	2.5	16
Distance bar trip guard	2.6	17
Photo-electric devices	2.7	17
Muting arrangement with photo-electric device	2.8	17
Interlocking guards	2.9	17
Limitations of early-rising type of interlocking guard	2.10	18
Development of early-rising type of interlocking guards	2.11	18
Guarding of press brakes used for "power press operations"	2.12	18
Guarding of press brakes when carrying out bending operations on 'narrow' work	2.13	18
Guarding required with individual punching tools	2.14	19
Secure fencing at back of machines	2.15	19
Hydraulic press brakes	2.16	19

Para. Page

Part III Tool Design

Devices for placing the workpiece between the tools 3.1 47
Common types of press brake operations 3.2 47
Main types of tools used in press brake operations 3.3 47
Back stops and gauges with front adjustment and locking . . . 3.4 47
Universal slide feed arrangements to enable fixed guarding to be used 3.5 48
Feeding arrangements and backgauge systems for use on planishing and other operations 3.6 48
Linking of safe tool design features with machine operating mechanism and component ejection arrangements 3.7 48

Part IV General

Inspection, examination and maintenance of press brakes and their guards 4.1 53
Inspection, examination and maintenance of guards 4.2 53
Selection and training of press brake operators 4.3 53
Employment of young persons on press brakes 4.4 53
Precautions during the changing or setting of tools 4.5 53
Use of mechanical handling equipment to insert or remove tools . . 4.6 54
Use of interchangeable nose-pieces with standard punch holder for 'V' bending operations 4.7 54
Instruction to setters 4.8 54

Appendices

I Automatic guard 57
II Interlocking guards 58
III Early-rising interlocking guard 59
IV Distance bar trip guard 60
V Photo-electric safety device. 61
VI Fixed guards 63

Members of the Committee (1964–1967)

†E. W. Hodgson	HM Senior Engineering Inspector of Factories (*Chairman*)
†F. C. Arnaud	HM Deputy Senior Electrical Inspector of Factories
†W. H. L. Brogden	Group Safety Officer, Pressed Steel Fisher Ltd., Cowley, Oxford
*H. D. Challen	Taylor and Challen Ltd., Constitution Hill, Birmingham 19 (Deep River Cottage, Wargrave, Berkshire)
*A. Gow	HM Superintending Inspector of Factories
†E. G. Hands	Standards Engineer, Central Services, Pressed Steel Fisher Ltd., Cowley, Oxford.
*L. R. Kealey	National Secretary, Transport and General Workers Union, Transport House, Smith Square, London, S.W.1
*J. R. Moore	"Draycot" 25 Stourbridge Road, Bromsgrove, Worcester
*H. Scanlon	Executive Councilman, Amalgamated Engineering Union, 110 Peckham Road, London S.E.15 (Now President of the Amalgamated Union of Engineering and Foundry Workers)
†A. L. Stuchbery	The Metal Box Co. Ltd., 37 Baker Street, London W.1
†J. D. Udal	J. P. Udal Ltd., Interlock Works, Court Road, Birmingham 12
†J. Hird	HM Engineering Inspector of Factories (*Secretary*)

The following were appointed to the present Committee, reconstituted in October 1967, in addition to those re-appointed from the former Committee:

G. J. Broughton	J. Broughton & Sons (Engineers) Ltd., Kings Norton, Birmingham
T. H. Burton	Hordern, Mason and Edwards Ltd., Birmingham
E. Hamilton	Wilkins and Mitchell Ltd., Darlaston, Staffs.
A. L. Hearsey	Analgamated Union of Engineering and Foundry Workers
J. P. Bishop	General and Municipal Workers' Union
A. W. Grimsey	HM Deputy Superintending Inspector of Factories

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*Not members of the present Committee.

†Members of the present Committee.

Members of the Press Brake Sub-Committee

J. A. DAVIS	HM Superintending Inspector of Factories Yorkshire and Humberside (Leeds) Division (*Chairman*)
A. ASHLEY	Vicker's Armstrong Ltd., Newcastle upon Tyne
G. R. BLAKELY	G. A. Harvey & Co. (London) Ltd. (now of Kirkstall Forge Co. Ltd.)
R. J. CORBETT	Joseph Sankey and Sons Ltd., Wellington, Shropshire
I. M. FURNIVALL	I.G.E. Control Equipment Ltd., Birmingham
J. A. GRAINGER	Roneo Ltd., Romford (now of S. Russell & Sons Ltd., Leicester)
J. HIRD	HM Engineering Inspector of Factories
*V. G. HOOPER	Bronx Engineering Co. Ltd.
H. W. WOODBRIDGE	J. Broughton & Son (Engineers) Ltd., Birmingham
J. T. TOOGOOD	HM Engineering Inspector of Factories (*Secretary*)

*Deceased.

To: The Right Hon. R. J. GUNTER, M.P.
Minister of Labour

Sir,

1. We have the honour to present our Seventh Report of proceedings which deals with safety in the use of press brakes. We appointed a technical Sub-Committee in 1960 to consider and report upon progress in the prevention of accidents at press brakes, the membership of the Sub-Committee being selected so as to represent HM Factory Inspectorate, the manufacturers of press brakes, the manufacturers of safety devices and the users of these machines. We attach the report of this Sub-Committee which contains not only general observations addressed to us, but also detailed recommendations, illustrative examples, diagrams and drawings, relating to fencing methods and to other matters affecting safety at press brakes.

2. The problem of applying effective safety devices (including, in particular, guards) to the tools of press brakes has long been one of great difficulty, and since 1945 there has been steady development and some application of such devices. It must be stated however that many of these machines have continued in use without any safeguards or with sub-standard safeguards under conditions which amount to breaches of section 14 of the Factories Act 1961. There is, therefore, an urgent need for unremitting efforts to achieve satisfactory standards of fencing and of other related matters. In furtherance of these efforts, methods of safeguarding press brake tools are, inter alia, described and illustrated in some detail in this Report. In the specifications for safety devices, which include machine requirements, the Sub-Committee has endeavoured to integrate good current practice with proposals for further improvement. To this end, specifications given in our earlier report of 1952 have been revised and strengthened and where specifications have not previously been given, they have been added.

3. In our report of 1952, we said that it appeared to us there was a case for the making of regulations specifically for the use of press brakes under the powers given in the Factories Act. The effect of such action, had it been taken, would have been to legalise in certain cases a standard of protection less than that of secure fencing; our reason for recommending this action was the apparent unattainability of the higher standard, for those cases, at the time. We had to decide whether, or not, in presenting this report, we should repeat our recommendation of 1952 regarding regulations. We concluded that we need not do so, but before reaching this conclusion we took certain considerations into account. In the first place the recommendations of the Sub-Committee represented a distinct advance on current safeguarding standards which were themselves an improvement on those of 1952; if they were adopted secure fencing for the tools of press brakes would in many cases be attained and in other cases, a standard closely approaching this. Furthermore, the standard of fencing of tools in the latter category should be raised eventually if the longer term recommendations in the report are implemented. In the second place, a higher standard of reliability of the mechanically powered press brakes and their safety devices might reasonably be expected to accrue from the inspection, examination and maintenance requirements of the Power Presses Regulations 1965.[1] Despite the generally favourable outcome of both considerations, one

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[1] The Power Presses Regulations 1965 (SI 1965 No. 1441) HMSO.

serious residual problem emerged which called for, and received, appropriate action before the above conclusion could be reached. The problem concerned those safety devices which are covered by, and are in conformity with, specifications in Appendices 2 to 5 and which in association with mechanical press brakes, are not fully proof against certain malfunctions of the press brake mechanism. Although the Sub-Committee's recommendations in respect of the development and future fitting of arrestor devices or their equivalent should, if followed, lead ultimately to a wholly satisfactory fencing standard in these cases, we considered it essential, if delay (and statutory action) was to be avoided, to introduce into the report safeguards designed to ensure that the higher standard was attained within a limited and specified time. After prolonged discussion agreement was reached, with the concurrence of the Sub-Committee, firstly, that such action was feasible and secondly on the details of the safeguards to be introduced. Particulars of the problem, the agreement and the proposed safeguards are given in the following paragraphs.

4. The types of safety devices which, in association with mechanical press brakes presented the above-mentioned residual problem, and which earlier had presented an even greater one, comprise the following:

(a) Early-rising type interlocking guards (specification in Appendix 3).
(b) Photo-electric devices (Appendix 5).
(c) Distance bar trip guards (Appendix 4).
(d) Interlocking guards fully interlocked with the clutch but without guard-control. (Appendix 2).

Although there had been some development of these safety devices after 1952 and before the appointment of the present Sub-Committee, weaknesses which had in 1952 influenced our attitude to the making of regulations still existed at the time of this appointment. Their principal weakness lay in an inability to give, in certain contingencies, protection equivalent to that afforded by conventional power press guards; in particular against uncovenanted overrun of the crankshaft past the top dead centre position. You will note that the present Sub-Committee, while strongly supporting the need for positive overrun protection, was unable to reach agreement on a proposal that the specifications for these particular safety devices should include a requirement for the fitting of arrestor devices which would prevent overrun strokes under power. As a consequence, it was decided that the relevant requirement in each of the specifications (Appendices 2 to 5) should only be for protection against non-powered overrun. The Sub-Committee's decision not to specify arrestor devices arose mainly from the absence, in the opinion of a number of members, of sufficient experience of their use on press brakes to enable it to be said with certainty that they would in all cases be a practicable proposition and would not be liable to damage the machines. Moreover non-powered overrun appeared to be not uncommon, powered overrun rare, and the arrangements recommended in the report for early detection of overrun seemed likely, if adopted, to reveal faults before they became dangerous.

5. While appreciating the reasons for the Sub-Committee's view and noting the recommendations in its report on the need for continued progress with arrestor devices, we decided, after much discussion, that the experience gained with these devices on conventional presses alone would enable us to state that, given careful design, their fitment and use on all mechanical press brakes was already a practicable proposition, no basic difference in the technical problem between presses and press brakes being apparent. We considered it necessary therefore to arrange a meeting between representatives of this committee and members of the Sub-Committee to discuss the latter's doubts concerning arrestor devices. At this meeting, agreement was reached with the Sub-Committee (see third paragraph of this letter) that the fitting of arrestor devices to press brakes was not only feasible but would be a practicable requirement provided sufficient time was allowed for its implementation, the lesser standard of overrun protection in the specifications being allowed to stand in the meantime. We are now therefore in a position to advocate, with the concurrence of the Sub-Committee, that where the types of safety devices listed in the fourth

paragraph of this letter are in use, they should be associated with arrestor devices within five years of the date of first publication of this Report. These devices should be capable of stopping crankshaft movement before danger can arise from the tools, firstly in the event of an unconvenanted stroke, however caused, and secondly when the operative part of the guard or other safety device permits access to the tool area during the dangerous part of crankshaft rotation. The period specified for implementation was, we felt, adequate while still being sufficiently short to warrant our recommendation that statutory action need not be taken. In the furtherance of our wish that safeguards be introduced into the report to ensure that the agreed higher standard of fencing is attained within the specified time, footnotes giving details have been added to the specifications in Appendices 2 to 5.

6. The Sub-Committee has put forward, very rightly in our view, a number of major recommendations in regard to machine design and we hope that the manufacturers and users of these machines will give their utmost co-operation in adopting the recommendations for new design and will be prepared to alter existing machines on the lines proposed. These are technical matters not readily or necessarily appropriate for legislative action; rather we would suggest that they be taken as an indication of the kind of development needed so that standards such as those recommended will ultimately become the 'norm'. We certainly feel that the manufacturers of mechanical press brakes should incorporate arrestor devices (or their equivalent) as standard equipment on new machines without delay with a view to this becoming general within three to five years. We also feel that they should be in a position to provide such devices so that all existing machines which require them can be so equipped within five years. The performance of these devices should be as broadly outlined in the previous paragraph of this letter.

7. One particular form of safety requires mention and that is the photo-electric device. The specification for this, given in Appendix 5, is broadly the same as in the 1952 Report, but some amendments have been made. We are now, however, advised that there is room for fresh thinking in line with developments which have taken place in the electronic field since the first specification was prepared. The Electrical Engineers' Advisory Panel set up by your Committee is currently studying this problem.

8. We consider that the Sub-Committee has done a most valuable piece of work. If its recommendations, together with the agreed additional recommendation on arrestor devices, are adopted, there will be a substantial improvement in the safe working of these machines with consequent reduction in accidents and, it is hoped, with the benefits in production which frequently accrue from confidence in the safety arrangements.

9. We wish to emphasise that this report ought not to be regarded as final, dealing as it does with difficult problems which require constant attention. We would like to assure you that we shall give continuous study to the subject, not least to the problems of hydraulic press brakes which are now being used in greater numbers, so as to enable us to advise you periodically on progress.

10. We wish to express our great appreciation of the services rendered by Mr. J. Hird, Secretary of this Committee, Mr. J. T. Toogood, Secretary and Mr. D. Ferguson, former Secretary of the Sub-Committee appointed by us. Their wide knowledge of the industry and their technical ability have been of great assistance to us in our work.

We have the bonour to be, Sir,
Your obedient servants,

(Signed) E. W. HODGSON (*Chairman*)
F. C. ARNAUD
W. H. L. BROGDEN
H. D. CHALLEN
A. GOW
E. G. HANDS
L. R. KEALEY
JOHN R. MOORE
H. SCANLON
A. L. STUCHBERY
J. D. UDAL
J. HIRD (*Secretary*)

12th October 1967

JOINT STANDING COMMITTEE ON SAFETY IN THE USE OF POWER PRESSES

Report of the Technical Sub-Committee on Safety in the Use of Press Brakes

To Mr. E. W. Hodgson, M.I.Mech.E., Chairman, Joint Standing Committee

Sir,

1. We were appointed in 1960 to consider and report upon recent progress in the prevention of accidents at press brakes.

2. There have been three earlier reports on press (or bending) brakes – two issued by the Joint Standing Committee on the Safety of Heavy Power Presses in 1945 and 1949 and the other issued by the Joint Standing Committee on Safety in the Use of Power Presses in 1952.

We examined these reports, and in the hope that our report will be published and will be read by makers and users of press brakes, we have incorporated from these earlier documents matters which we consider to be relevant.

3. Many of the problems of providing secure fencing for the tools of press brakes are similar to those encountered when dealing with power presses, and we are indebted to the Report of the Committee on Safety in the Use of Power Presses 1945 and the various Reports of Proceedings of the Joint Standing Committee on Safety in the Use of Power Presses for information on certain aspects of their problems. However, in the case of press brakes there are two fundamental differences which have a bearing on the problems of providing secure fencing:–

(a) *Machine Design.* The very nature of the press brake with its long narrow tool slide and bed accentuates the problem of providing and maintaining close guards, whether fixed or interlocked, which will prevent access to the tools. In addition, the almost universal use of band-type brakes with complex linkage and the absence of single-stroking, overrun prevention and fall-back devices, tend, in the absence of careful maintenance, to lead to serious accidents even when guards which might appear to be satisfactory are fitted.

(b) *Wide Range of Work.* The use of press brakes for both pressing and bending jobs of every conceivable size and shape makes the problem of finding a universal guard extremely difficult. If accidents are to be prevented by the use of a guard and only one particular guard is provided it must be accepted that this may result in some limitation on the use of the machine.

4. Our recommendations deal with the problems of machine design for both new and existing machines. We are confident that if press brakes are manufactured to the standards suggested, most of the serious types of accidents which have occured due to malfunctioning of the machine will be prevented. It is recognised that experience may show that improvement in design of press brakes may achieve such a standard of reliability as to render superfluous devices intended to deal with malfunctioning of the machine. We are also of the opinion that provision of the devices recommended to existing machines should also deal with malfunctioning of these machines and prevent accidents due to this cause.

5. By including provisions for protection against certain known machine malfunctions into the recommended specifications for guards, we have placed the onus of manufacturing these devices on to the shoulders of the guard makers as it is known that the devices are not provided on existing machines. We are, however, strongly of the opinion that this protection should be incorporated into new machines by the manufacturer. The co-operation of the manufacturers in making available such devices that could be fitted to existing machines would also be welcomed.

6. We have made recommendations for the provision of devices to prevent overrun where certain types of guards are used. We are aware that it will not be practicable in many cases for these recommendations to be implemented at once, but we hope that users of press brakes will give this matter their full attention and that overrun protection devices will be fitted to all press brakes within a reasonable period of time, dependent upon the number of machines involved and the facilities available for producing the devices. We see no reason why, when new guards are fitted to either new or existing machines, they should not comply with the relevant specifications contained in the appendices to this Report and strongly recommend that they do so.

7. This report has been divided into separate parts although all the aspects which have been examined relate to one issue only – the prevention of accidents. This has been done to make the report more readable but it is not thereby suggested that factory occupiers need not study the recommendations on the design of new machines. It is hoped that they will do so and bear the points in mind when ordering new plant.

J. DAVIS (*Chairman*)
A. ASHLEY
G. R. BLAKELY
R. J. CORBETT
I. M. FURNIVALL
J. A. GRAINGER
J. HIRD
V. G. HOOPER*
H. W. WOODBRIDGE
J. T. TOOGOOD (*Secretary*)

*Mr. Hooper died 18th November 1965.

PART I: DESIGNING PRESS BRAKES FOR SAFETY

1.1 The effectiveness of most types of guards now used on press brakes depends on good and reliable brake and clutch performance. We have examined the factors which determine the performance of these two components with particular care.

1.2 In our view, the items which merit special attention are:
- (a) the arrangements for engaging and disengaging the clutch and releasing and applying the brake,
- (b) the connection between clutch and brake,
- (c) the clutch,
- (d) the brake,
- (e) the single-stroke device,
- (f) the arrangements for prevention of gravity fall-back of the beam,
- (g) the arrangements for prevention of overrun past top dead centre and of repeat strokes.

1.3 Items (a) to (d) will of necessity be incorporated in any mechanical press brake of the kind considered by us but (e), (f) and (g) are not vital to the operation of the machine. Items (e), (f) and (g), do not seem to be present on most machines unless incorporated with guarding, even though as early as 1945 the Joint Standing Committee on the Safety of Heavy Power Presses[1] recommended in its report that each machine should be fitted with effective devices to prevent gravity fall of the beam by fall-back due to brake defects, and that the development of devices to prevent overrun past top dead centre after clutch disengagement, such overrun being occasioned by brake defect, should be studied. Both these arrangements are most desirable even when considered irrespective of guarding as they provide protection in the event of machine failure, but we consider them to be essential when certain types of guards are in use. Furthermore, a single-stroke device (also recommended in the report mentioned above) is a necessary prerequisite to the fitting of overrun protection arrangements because it determines the normal point at which the crankshaft stops.

1.4 Most press brakes with mechanically-operated clutches are foot-operated by pedal or treadle. The various parts of the linkage from the pedal or treadle to the clutch should be of adequate dimensions and be properly protected. Where guides are necessary they should be provided, should be properly spaced and have proper facilities for lubrication. A most important linkage is that from the clutch to the brake. These linkage arrangements were found to be of poor design and construction on many existing machines where the band or shoe brakes provided could not be directly connected to the clutches owing to changes in the direction of thrust. This factor, together with arrangements involving wide separation of clutch from brake, often leads to complex linkages which are considered to be undesirable. We are of the opinion that direct connection of the clutch and brake is practicable since we examined a mechanical clutch press brake of recent design which incorporated this feature. The brake and clutch were a single unit, the plate-type brake and clutch being connected by a central rod, brake application and clutch disengagement being effected by compression springs disposed around a pitch circle, a similar arrangement to that commonly used on presses and press brakes with air-operated clutches. It is strongly recommended that, whatever the type of clutch and brake used on press brakes, the linkage connecting them should be as short and as direct as possible.

1.5 With regard to existing machines it is recommended that the above defects should be eliminated as far as possible. In any case, care should be taken to ensure that linkages are kept in good order, are properly lubricated and particularly are not damaged so as to interfere with the adjustment or so that they can foul the machine structure, as this can lead to a position where the brake may not be effectively applied. In such a situation an uncontrolled position between clutch fully off and brake fully on could arise and it is recommended that anything likely to restrict or jam the clutch-brake and pedal linkage or cause excessive wear should be eradicated. Where crude arrangements such as elongated or over-size holes exist to facilitate changes in direction of motion, proper universal joints should be substituted. Excellent small universal joints can now be obtained.

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[1] Report of the Joint Standing Committee on the Safety of Heavy Power Presses Bending Brakes 1945. HMSO.

1.6 When considering clutch design we only concerned ourselves with friction clutches as it was found that this type of clutch was invariably used on conventional press brakes. There are indications that the clutches are on the whole more reliable than the brakes in general use on these machines. Complete clutch failure resulting in repeat or uncovenanted strokes is rare, but our attention has been drawn to occurrences of this nature caused by complete or partial disintegration of the lining, or the formation of dust in the casing, causing drag in the clutch. We examined the recommendations on friction clutch design for power presses contained in Appendix 4 of the Fourth Report of proceedings of the Joint Standing Committee on Safety in the Use of Power Presses[1] and find that some of them are equally applicable to friction clutch design for all press brakes. These recommendations are:

(*a*) Clutches and brakes should be designed so as to perform satisfactorily when engaged and disengaged momentarily each time the top dead centre position is reached under conditions of maximum sustained production.

(*b*) The design should provide for adequate dispersal of heat so as to prevent excessive temperature rise of the working parts.

(*c*) Sufficient working clearance should be provided so as to ensure that, under the severest conditions of operation, friction drag leading to undesired movement of the driven members will not take place.

(*d*) Arrangements should be made to prevent the accumulation of debris evolved from frictional surfaces in place where it might give rise to clutch drag or seizure, and for its effective dispersal.

(*e*) Effective means of lubrication of bearing surfaces should be provided or such other treatment given as will minimise the chance of scuffing or of seizure. Particular attention should be given to the means of lubrication of the continuously rotating member.

(*f*) Consistent with other mechanical considerations, the stage between brake release and clutch engagement, and between clutch disengagement and brake application, should be as small as possible in dimension and in time.

(*g*) The springs used for applying the brake and withdrawing the clutch should be safely rated and be sufficient in power to secure prompt clutch withdrawal and effective brake application. Where springs are disposed on a pitch circle care should be taken to ensure that all the springs are closely uniform in dimension and rating. A single spring should not be relied upon for this duty. The means for loading the springs should be such that when appropriately adjusted the springs can be locked to prevent risk of slacking back. The arrangements for spring housing, guiding and of guide pins should be such as to minimise the risk of binding.

(*h*) Effective arrangements should be made to prevent the penetration of oil to friction surfaces.

1.7 It was found that the majority of brakes in use on press brakes were band brakes, and our experience indicated that although this type of brake can usually fulfil its function adequately if properly adjusted, regularly checked and regularly maintained it is probably the least reliable of available brakes. Some firms have experienced a good deal of band brake failure, and others very little, though it seems that almost every user has at some time or another experienced brake failure which could have caused a serious accident. A probable reason for complete band brake failure is over-tightening which is more likely to occur if a brake is inadequate for its purpose. We are of the opinion that band brake design could be improved as brakes are frequently too small in area and often full use is not made of the area available. Careful consideration should also be given to anchoring arrangements and to means for preventing contamination of brake linings by oil seeping from adjacent bearings. For reliability and braking efficiency the plate-type or possibly the disc brake are considered to be the most suitable for use with press brakes, and it is recommended that either one or the other should be incorporated in the design of new press brakes. The plate-type of brake lends itself to a simple arrangement if associated with a plate-type clutch as the two can be arranged coaxially and directly connected without complex intervening linkage. Replacement of band brakes on existing machines presents a problem and there may be difficulties in incorporating one of the brakes recommended above for new machines; even so, we feel that, where possible, and particularly where poor brake performance is experienced, users of machines with band brakes should consider the replacement of these brakes by brakes of one of the types mentioned above or, if this is found to be impracticable, by shoe brakes of the floating type.

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[1] See also the Fifth Report of Proceedings of the Joint Standing Committee on Safety in the Use of Power Presses, or Power Press Safety Code, published since the above was written. Among other things this Report contains these requirements (see page 11) and other press design and equipment requirements in a slightly revised form. The Fourth and Fifth Reports can be obtained from HMSO, price 2s. 6d. and 2s. 3d. respectively.

1.8 Many press brakes in use were found not to be fitted with single-stroke devices. This means that the point of clutch disengagement is more likely to be at the discretion of the operator than if such a device were fitted and it is considered that this has serious disadvantages, not the least being that the operator is able to compensate for brake deterioration by early release of the pedal or other controls, thereby masking the fact that the brake requires attention. It is recommended that every mechanical press brake should be fitted with a device for positively initiating clutch withdrawal which will effectively render the press single-stroking. This same recommendation was made in 1945 in the Report of the Joint Standing Committee on the Safety of Heavy Power Presses[1]. In our opinion this single-stroke device should be positive in relation to the crankshaft rotation and should disconnect the pedal or other operator's control from the clutch through a cam or lug on the crankshaft, but could thereafter rely upon a spring or springs or a weight to disengage the clutch and apply the brake. While it is usually effected mechanically, single-stroking is sometimes achieved by the introduction of a pneumatic link into the linkage from the pedal or other control to the clutch and this method is often used in conjunction with certain types of guards. It is found that this system works well in practice. It is considered that a single-stroking device should be fitted as standard equipment on every new press brake and that those machines now in use should be modified to incorporate the device.

1.9 We also consider it desirable that it should only be possible to adjust the cam of a single-stroke device by a limited amount after it has been initially set. The object of this is to prevent the use of cam adjustment to compensate for, and thereby mask the effects of brake deterioration or of other defects that may cause overrun. It is vital that if such a defect occurs its effect should be apparent and should be dealt with by attention to the defect itself and not by adjustment of the point of clutch disengagement. If it is not possible to adjust the single-stroke cam by more than a limited amount, then brake deterioration will result in drift of the crankshaft over top dead centre and it is this condition which it is considered should be made immediately apparent. A warning bell or light can be used to signal this drift over top dead centre after it has reached a certain pre-determined point. The same effect could be achieved with greater certainty by incorporating an arrangement of secondary disconnection of clutch from the pedal at a point where drift or overrun exceeds say 10° past top dead centre; this disconnection could be of such a nature that it is necessary to manually reset it before the press can be stroked again.[1] While it is considered that there is merit in such devices we are of the opinion that if complete protection against overrun or drift is to be obtained then more positive methods such as those described in the following two paragraphs must be used.

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[1] Report of the Joint Standing Committee on the Safety of Heavy Power Presses Bending Brakes, 1945. HMSO.

1.10 Careful consideration has been given to the question of the provision of protective devices to prevent overrun past top dead centre, on which, as far as is known, there has been no development by press brake manufacturers. We have, however, examined two developments for preventing overrun, one initiated by a press brake user and the other by a guard maker. The first of these developments demonstrated to this Sub-Committee was a positive overrun stop fitted to a machine having an early rising type of interlocking guard, the user fitting the stop after experiencing uncovenanted overrun. The device (see Figs. 1 and 2) was demonstrated under conditions firstly of simulated brake deterioration and secondly of complete brake failure. In both cases it was completely effective in arresting the beam. Some Members were, after seeing the demonstration, apprehensive of damage to the machine in case of complete brake failure and were of the opinion that machine manufacturers and guard makers would be reluctant to fit the device for this reason. It was felt, however, that if some method, hydraulic or otherwise, were used to absorb the energy over some 15° or 20° of angular travel of the crank, the device may well be acceptable. The device we saw was intended to arrest the beam in the case of non-powered overrun caused by brake deterioration or failure and was not designed to cater for power strokes due, for example, to failure of the clutch to disengage. If some method of absorbing energy were used as mentioned above, the device may possibly cater for powered strokes should they take place with the guard open.[2]

1.11 A second development demonstrated, the one initiated by the guard maker, involved the use of arrestor brakes. Such brakes have been used on power presses for some years, but until recently they have not been used on press brakes. The guard maker concerned has however fitted arrestor brakes to two press brakes (one example is illustrated at Fig. 3), one of which was of 240 tons capacity. The brakes, which in these cases were additional to, and separate from, the normal machine brakes, stopped the beams smoothly in a short distance. They consisted in principle of caliper type disc brakes, hydraulically intensified. We saw one of these arrestor brakes demonstrated and were most impressed by its efficiency. We consider that this type of intensified brake can provide complete protection against powered overrunning or repeat stroking, or an uncovenanted power stroke from a top dead centre position of the crankshaft, by preventing movement past top dead centre to such an extent that trapping between the tools can occur. We would not, however, exclude the possibility that similar results could be achieved in other ways, such as, by the intensification by fluid or mechanical means of the brake normally used for stopping the machine, as is current practice on some power presses.

1.12 We have to consider whether, in the specifications for certain types of guard which permit access to the tools while the crankshaft is in motion, we should recommend that arrestor brakes giving the complete protection referred to above should be fitted to the machines concerned. We came to the conclusion, somewhat reluctantly, that while this full protection is highly desirable, as it would protect the operator from malfunctioning of the machine, it is not practicable at this time to make it a condition of guarding. Provisions have, however, been included in certain of the guard specifications for protection against non-powered overrun, which is not as difficult to accomplish. The reasons that led us to this conclusion are as follows:

At the time of these considerations only two cases were known to us where arrestor brakes were in use, and while the example seen performed most satisfactorily when tested, some members of the Committee considered that there was not enough experience of these devices to be certain that they are a practical proposition on all types of press brakes: some doubts were expressed as to whether all press brakes are so constructed that they are capable of absorbing without damage the stresses to which they may be subjected by an arrestor brake. The manufacturer of the device, a leading firm of guard makers, however, has no such doubts and considers that experience indicates that these devices can be fitted to any known type of press brake without undue stress or strain being imposed on the machine. In some cases, however, the cost of supplying the device would be expensive. Secondly, we have been told by guard makers that there is a considerable amount of special design work involved relative to each individual type of machine. This would place such a burden on guard makers' existing design capacity that the rate of guarding press brakes would be decreased temporarily until such time as this capacity could be increased. Thirdly, as the bulk of overrun experienced is non-powered, then protection to the standard we have recommended should prevent all but a small percentage of accidents arising from malfunctioning of the machine. Lastly, it is expected that the Power Presses Regulations 1965, which require periodic thorough examination of press brakes, will result in a higher standard of maintenance, particularly of clutch and brake, and thereby will have a favourable effect on the number of accidents due to malfunctioning of machines.[1]

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[1] This, or an equivalent arrangement, has since been fairly widely adopted by guard makers.

[2] A subsequent and improved model incorporates a buffer spring and is associated with a replaceable shear pin in the machine drive; this arrangement gives substantial equivalence to an arrestor brake, ensuring prompt arrest of the crankshaft without damage to the machine or the device in the event of fully powered overrun.

In spite of the foregoing, however, we strongly recommend and hope that progress will continue to be made in providing arrestors that will be capable of arresting a power stroke of a press brake[2]. In this way it is anticipated that experience and knowledge of these devices will increase to the point where the question of fitting such arrestors can be reconsidered.

1.13 To obtain the best control over a machine and to enable the beam to be brought to rest in the shortest possible time without damage to the machine or undue wear to the braking surfaces, the inertia of the moving parts other than the flywheel should be reduced to a minimum; this should also give the best clutch control condition. One large manufacturer of press brakes informed us that they were able to reduce the inertia of these moving parts of a press brake by 40% by careful redesign, and it is recommended that manufactures should give careful attention to this point when designing new machines.

1.14 In the past the use of air-clutch machines has been confined to certain heavy work or to other work that does not require close control over the beam in the form of inching. Recent developments, which involved controlling the pressure of air to the clutch cylinders, have enabled inching to be carried out on machines of this type as easily as with mechanically-operated clutch machines and this may well lead to an increase in the number of air-clutch machines. The design of the modern air-clutch press brake follows the same pattern as that of most air-clutch presses generally, this is to say it has a clutch of the multiple or single plate-type together with a brake of similar construction, the two being mounted coaxially and coupled directly to each other to give simultaneous clutch disengagement and brake application, the brake being applied and the clutch held out of engagement by a series of strong springs disposed around the clutch and brake unit. The recommendations on general friction clutch design contained in para. 1.6 of this Report are generally applicable to air-clutch machines. Repeat strokes can and do take place with air-operated friction clutches, however, due to retention of air in the clutch. This can be caused by failure of switches, sticking of solenoids and malfunctioning of air valves in the case of pneumatically and electro-pneumatically controlled clutches. Control equipment should be so designed and constructed as to lessen the possibility of repeat strokes from these causes.

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[1] The Power Presses Regulations 1965 (SI 1965 No. 1441) became operative on 20th July 1966.

[2] Since this report was written, the Joint Standing Committee, with the concurrence of this Sub-Committee, has advocated that where the types of safety devices specified in Appendices 2, 3, 4 and 5 are in use on mechanical press brakes, they should be associated with arrestor devices within five years of first publication of this report. Footnotes to this effect have been added to the specifications. It has also been advocated that manufacturers should incorporate arrestor devices as standard equipment on new machines without delay and should be in a position to equip existing machines which require them within five years. For details please see paragraphs 5 and 6 of the letter of presentation to the Minister, page 1 of this Report. Paragraphs 8 to 11 of the Fifth Report of Proceedings of the Joint Standing Committee (see footnote to paragraph 1.6 of this Report) deal with arrestor brakes for power presses.

1.15 The matter of control of air-operated friction clutch presses has been dealt with in the Fourth Report of Proceedings of the Joint Standing Committee on Safety in the Use of Power Presses. We commend this Report to manufacturers of pneumatically or electro-pneumatically operated press brakes, as we are of the opinion that design considerations are much the same with air-operated clutch press brakes as they are with similarly operated power presses[1].

1.16 We know of few cases where accidents have been due to gravity fall-back of the beam, but we have seen machines fitted with devices to prevent this occurrence. One, which consisted of a ratchet and pawl, was simple and effective. While little is known of accidents due to gravity fall-back, there is evidence of accidents due to gravity fall-forward; for this, and to prevent any dangerous overrun, we have advocated the provision of effective means for preventing any uncovenanted overrun on new machines, and on existing machines where certain types of guards are used. When overrun stops are fitted, devices to prevent fall-back must be used in conjunction with them, as if a machine overruns due, say, to brake failure, and is arrested by the stop, the crank is likely to rebound on striking the stop, and fall-back may result.[2]

1.17 We have noticed an increase in the number of hydraulic press brakes in use both of British and Continental manufacture. We have no knowledge of any special risks with these that are not present with mechanical machines, and are of the opinion that the risk of repeat or uncovenanted strokes is less than with mechanical machines. We consider, however, that designers of hydraulic press brakes, whether the valves are mechanically or electrically controlled, should keep 'failure to safety principles' firmly in view.

1.18 Accidents have occurred when press brake operators or their helpers have accidentally stepped on clutch operating pedals or treadles, or these controls have been depressed through tools or materials falling on them. We strongly recommend that treadles should be eliminated on new machines at least, and that pedals on new machines and both pedals and treadles on existing machines should be shrouded to prevent this type of accident.

[1] This should be read in conjunction with the Fifth Report of Proceedings of the Joint Standing Committee published since the above was written. (See footnote to paragraph 1.6 of this Report).

[2] Figs. 1 and 2 show an overrun stop associated with an anti-fall-back device.

Summary of Main Recommendations for Machine Design for Safety

	New Machines	Existing Machines
1	Provision of a single-stroking device. See paragraphs 1.8 and 1.9	Provision of a single-stroking device. See paragraphs 1.8 and 1.9.
2	Provision of effective positive means for preventing overrun[1]. See last part of paragraph 1.9 and paragraphs 1.10 to 1.12.	Provision of effective positive means for preventing overrun where certain types of guards are used.[1] See last part of paragraph 1.9, paragraphs 1.10 to 1.12 and Appendices 2, 3, 4 and 5.
3	Provision for prevention of gravity fall-back where necessary (e.g. where overrun stops are fitted). See paragraph 1.16.	Provision for prevention of gravity fall-back where necessary (e.g. where overrun stops are fitted). See paragraph 1.16.
4	Plate-type brake direct coupled to a plate-type clutch, or caliper disc brake(s) connected with suitable clutch. See paragraphs 1.7 and 1.4.	Replacement of band brakes if braking performance is continually poor. See paragraph 1.7. Improvement of clutch to brake linkage if necessary. See paragraph 1.5.
5	Good clutch design. See paragraph 1.6.	
6	Good linkage from pedal or treadle to clutch on mechanically operated clutch machines. See paragraph 1.4.	Linkages should be kept in good order, should be well lubricated and not damaged. See paragraph 1.5.
7	Provisions in machine construction so that back stops can be arranged for adjustment from the front. See paragraph 3.4.	Arrange back stops for adjustment from the front where possible. See paragraph 3.4.
8	Pedal should be shrouded to prevent accidental depression. Treadles should not be used. See paragraph 1.18.	Pedals and treadles should be shrouded to prevent accidental depression. See paragraph 1.18.

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[1] See paragraphs 5 and 6 of the letter of presentation to the Minister on page 1 of this Report and footnotes to Appendices 2, 3, 4 and 5.

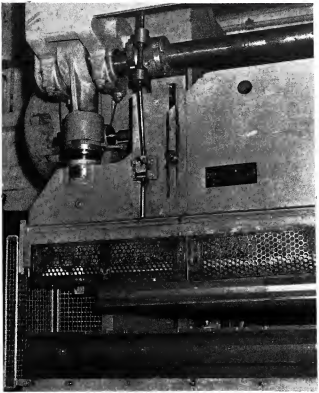

Fig. 1. Press brake fitted with an overrun stop and anti-fall-back ratchet and pawl. The overrun stop is so arranged that it is operated by the early-rising interlocking guard to prevent overrun past top dead centre if the guard is open.

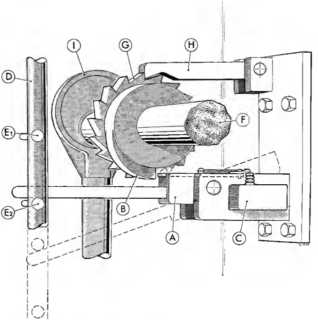

FIG. 2. Diagrammatic arrangements of overrun stop and anti-fall-back device shown in Fig. 1. (See paragraphs 1–10 and 1–16 of this Report). (Presented by AEI Ltd., Rugby).

- A. Overrun stop.
- B. Stop on eccentric shaft.
- C. Limit switch.
- D. Rod carrying early-rising guard screen.
- E.1 and E.2 are pegs which control the overrun stop between the limits of guard movement. Position shown in full is with guard fully up and the overrun stop in the operative position. Dotted lines show the guard fully down with the overrun stop carried down clear of the stop B on the eccentric shaft.
- F. Eccentric shaft.
- G. Anti-fall-back ratchet.
- H. Anti-fall-back pawl permitting rotation in one direction only.
- I. Eccentric rod.

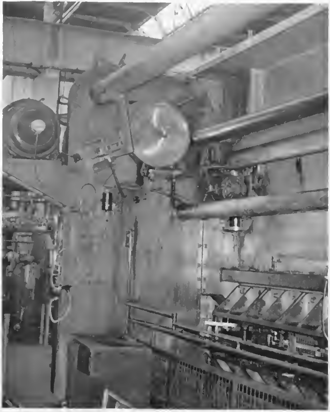

FIG. 3. Arrestor brake fitted to press brake. An arrestor brake can be used in conjunction with various types of guards or other safety devices or can be fitted independently of guarding.

PART II: SAFEGUARDING OF PRESS BRAKES

2.1 We examined the methods used to guard press brakes and found that four basic means are employed. They are:

(*a*) Fixed guards.
(*b*) Automatic guards.
(*c*) Trip guards including distance bar trip guards and photo-electric devices.
(*d*) Interlocking guards.

2.2 Fixed Guards

The use of conventional fixed guards is limited by the nature of the work performed on press brakes, because when work is bent it is difficult or impossible to remove it through an opening small enough to prevent access of a hand or fingers. The use of such fixed guards can be extended in some cases if methods involving feeding or removal of components from the end of the machine are employed. Our attention has been drawn to the increasing use of a simple type of hinged guard (Figs. 4 to 8) which consists of an apron across the front of the tool, this apron being so hinged or pivoted horizontally that it allows the apron to move close to the tool (see Fig. 9) when work is being bent and swings away from the tool to permit work removal. We consider that this type of guard is capable of development and could be used for a wide variety of work. We recommend its use providing it is so arranged that its arc of swing is limited by stops, making it impossible for fingers to gain access to the trapping zone between the tools. It is emphasised that fixed fencing is the best method of fencing and every effort should be made to use it wherever possible.

2.3 Automatic Guards

Automatic guards have as their object the removal of a person from the danger area before trapping can occur. The guard usually takes the form of a screen that moves outwards from the tools as the beam descends (Fig. 10). This body-push-type guard has in the past had only a limited use on press brakes mainly because, without either raising the machine or lowering the standing position of the operator, the height of the lower tool is usually too low as the top of the guard bar must be at least 42 inches from the standing level of the operator and must be below the level of the work. This type of guard has the advantage that it functions whenever a stroke of the machine takes place, whether intentional or unintentional, and we feel that it could be used much more than it is, if the fact is accepted that the machine may have to be raised by setting it up on a concrete plinth. With such a guard the speed of the machine is an important factor which affects the safe working of the guard for, if the speed of the machine is high the movement of the guard would be of such velocity that it would in itself cause injury, and for this reason we recommend that the maximum velocity of the front of the guard should not exceed 6 feet per second.

2.4 It is also considered that some limitation must be accepted in regard to the stroke of the machine and it is our conclusion that 2 inches is the minimum daylight between tools with which an automatic guard can be used with safety. (See Appendix 1).

2.5 Trip Guards

We have considered, in their two basic forms, safety devices incorporating a trip action as a method of fencing press brakes. They are:

(*a*) A distance bar trip guard (Fig. 11) incorporating a distance bar, with a screen to prevent access from below, which ensures that the operator must be placed at a safe distance from the danger area before the clutch can be engaged, and which will if pushed towards the machine, disengage the clutch and apply the brake.
(*b*) A photo-electric device (Figs. 12, 13 and 14) which prevents clutch engagement if the curtain of light is interrupted and which, if interrupted while the beam is in motion, immediately causes the clutch to be disengaged and the brake applied.

With both the above methods it is not generally possible for the operator to support work close to the tools and because of this, suitable supporting platforms with holding devices must be used. This is, in our view, an advantage as it is inherently dangerous to handle work close to the tools.

2.6 The distance bar trip guard described in the 1952 Report[1] has now successfully been in use for a number of years in conjunction with an electrically-controlled air-clutch machine (Fig. 13), both the electrical and air circuits being controlled by the guard so that double protection is obtained giving a high degree of reliability. An arrangement of this type could be designed to operate sequentially so that the pedal could be dispensed with.

2.7 Photo-electric devices for guarding press brakes have been in use for many years and we have been told by the principal manufacturers of these devices that they have supplied over 800. There is little evidence of trouble with the devices when constructed and installed to the standards laid down in Appendix 4 of the 1952 Report[1] (reproduced with amendments in Appendix 5 of this Report). Accidents have usually been due to the machine being used with the devices switched off. With proper arrangements and supervision this should not occur – switching off has usually been deliberate and in most cases the work could have been performed with the devices operative. It is therefore essential that the key for the cabinet containing the equipment and the key for the switches be kept in the personal custody of an 'authorised person'[2]. The photo-electric device has particular merit in that the operator must withdraw his hands behind the light curtain before the machine can be operated. This ensures that he cannot hold work close to the tools during the stroke of the machine and therefore involves the use of holding devices when narrow work is being performed.

2.8 A press brake fitted with a photo-electric device will not function if its light beam is interrupted by more than a specified area and the very nature of its safeguard prevents work being carried out that presents more than this area to the light beam. With work of 10 feet or so in width, distortion of the workpiece has often had the effect of interrupting the beam and causing the device to operate. Third and fourth operations that interupt the light beam with substantial raised edges also cannot be performed for the same reason. In order to widen the application of the device the leading makers have supplied, where the circumstances are appropriate, a cam-operated switch which renders the device inoperative when the tool has reached a position so close to the work that there is no risk of trapping, and keeps it inoperative until the press has reached top dead centre, when it again becomes operative. The photo-electric device is therefore operative during the dangerous part of the downstroke and inoperative during the upstroke. We consider that, providing electrical 'failure to safety' principles are preserved in the 'muting' arrangement, this modification still permits the device to comply with the requirements laid down in this Report. We do not, however, recommend the use of this 'muting' device if more effective measures can be adopted as it is vulnerable to maladjustment particularly when tools of varying penetration are used. When it is used great care should be taken to ensure that the device is in correct adjustment after tools are changed. It is essential that this adjustment is carried out by an experienced person authorised to do so by management.

2.9 Interlocking Guards

Interlocking guards currently in use on press brakes consist broadly of three types. The first has an enclosure fitted with a gate, fully interlocked with the clutch, which when raised gives access to the tool space and which is kept closed during a cycle by means of a guard-control. A variant of this guard can be converted to a distance guard for appropriate work.

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[1] Report of the Joint Standing Committee on Safety in the Use of Power Presses, Fencing of Press Brakes, 1952. HMSO.

[2] *Note:* For definition of authorised person see para. 2 (*f*) of Appendix 5.

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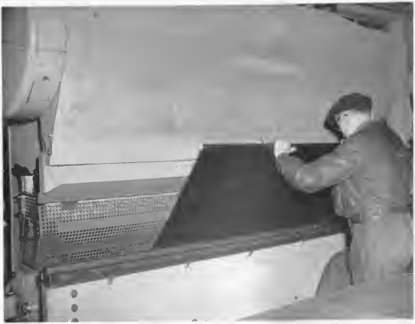

FIG. 4. Hanging screen fixed guard. The movement of this type of guard if not interlocked should be limited by stops so that it is not possible to gain access to the trapping area.

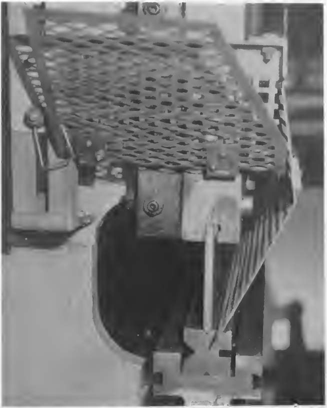

FIG. 5. End view of the hanging screen fixed guard, illustrated in figure 4 showing end guard raised.

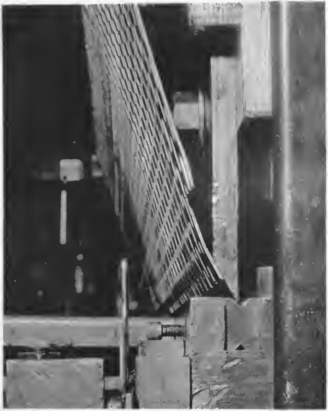

Fig. 6. Another example of hanging screen fixed guard, with end guard not shown.

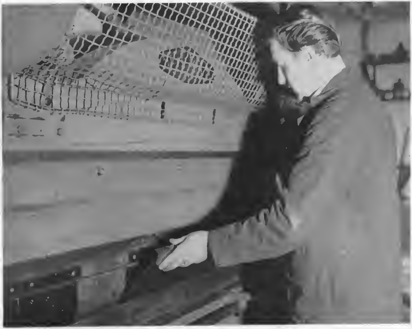

FIG. 7. Further example of hanging screen fixed guard.

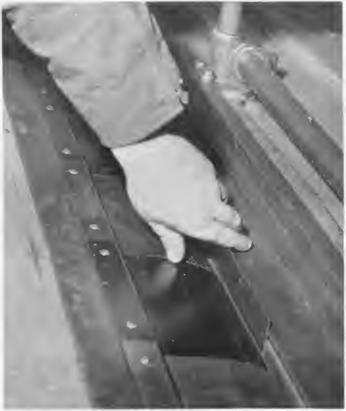

Fig. 8. Hanging screen fixed guard. This shows guard being used for narrow work.

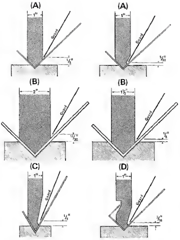

FIG. 9. Examples show how appropriate tool design can result in more effective safeguarding by permitting the guard screen of a hanging screen fixed guard (see Figs. 4 to 8) to closely approach the top surface of the bottom tool. The efficiency of the tooling does not appear to be affected. Tool designers could extend the basic principles shown here.

(A) Left hand view illustrates tooling which necessitates a $\frac{1}{2}$ in. gap below guard screen for screen to clear a right-angled bend. This gap would permit finger access to tools. Right hand view shows same tooling but with top tool machined away, allowing guard to be set with a $\frac{5}{32}$ in. gap which would prevent finger access.

(B) Left band view shows tooling which necessitates an unsatisfactory $\frac{13}{32}$ in. guard gap. Right hand view shows same bottom die but with $1\frac{1}{2}$ in. wide top tool instead of 2 in. as formerly; this allows guard to be set with a $\frac{1}{8}$ in. gap.

(C) This view shows modified tooling for a 60° bend. This modification allows guard to be set with a $\frac{1}{4}$ in. gap which would not be feasible without it.

(D) This view illustrates a suggested tooling arrangement for forming a double flange. The cut-away at the front of the top tool permits a $\frac{3}{16}$ in. guard gap to be set. The back cut-away accommodates the return bend.

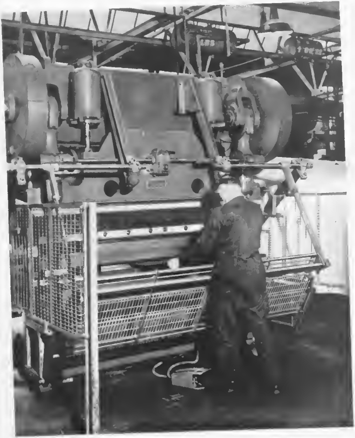

FIG. 10. Automatic guard. The bar of the guard removes the operator from the danger area.

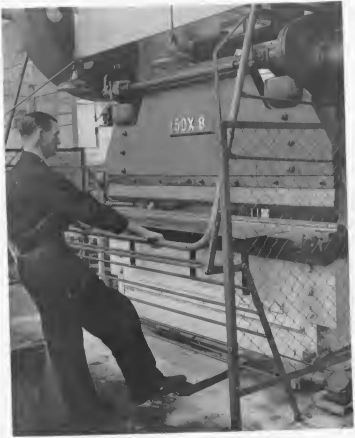

Fig. 11. Distance bar trip guard.

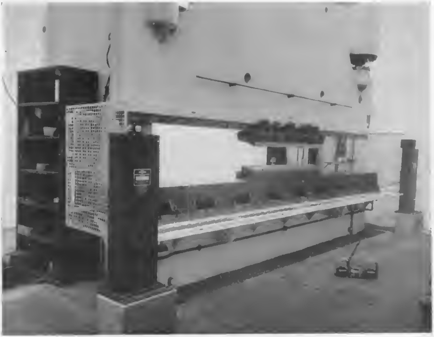

FIG. 12. Photo-electric safety device.

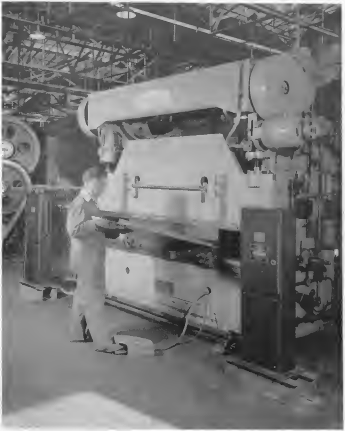

Fig. 13. Photo-electric safety device with muting arrangement to enable the light beam to be interrupted without stopping the machine after the dangerous part of the down stroke has taken place. (See paragraph 2.8).

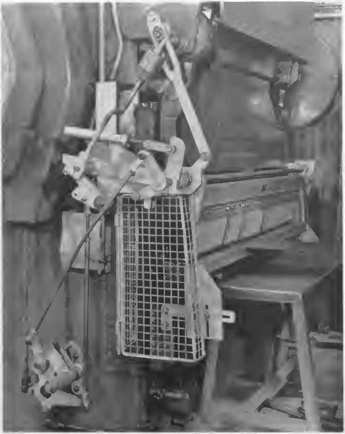

FIG. 16. Interlocking guard as in Figure 15 but with screen in closed position.

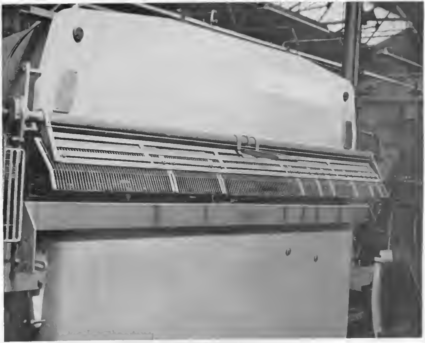

FIG. 17. Interlocking guard fitted to an upstroking hydraulic press. Screen in partially opened position.

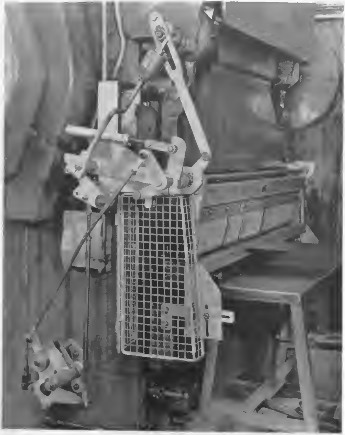

FIG. 16. Interlocking guard as in Figure 15 but with screen in closed position.

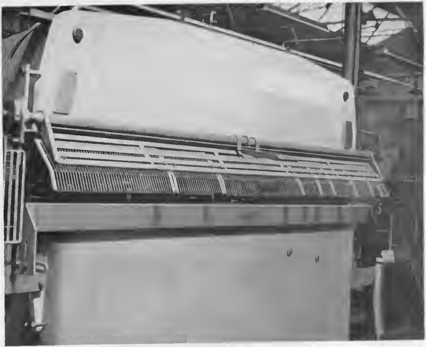

FIG. 17. Interlocking guard fitted to an upstroking hydraulic press. Screen in partially opened position.

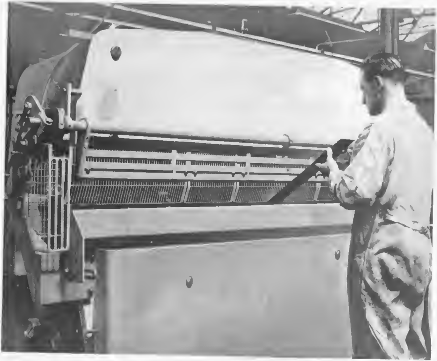

FIG. 18. Interlocking guard fitted to upstroking hydraulic press. Guard Screen in position close to beam permitting bending to take place.

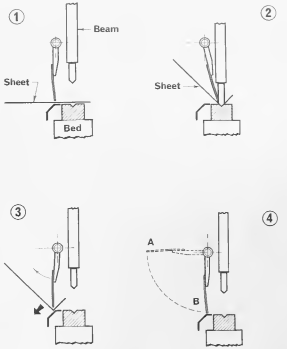

FIG. 19. Interlocking guard of type shown in previous illustrations (Figs. 15–18) applied to downstroking machine (See Figs. 15 and 16). The same principles apply when fitted to an upstroking machine (See Figs. 17 and 18) but the fixed platform and the screen are then designed to rise and fall with the beam during press operation.

Illustrations (1) (2) and (3) show guard setting in which bending takes place outside screen.

In (2) screen has moved towards tool to allow bending to take place; it can only do this when there is no longer a risk of trapping

In (3) arrow shows direction of removal of workpiece.

Illustration (4) gives an alternative setting of guard for bending and other work which is of narrow section. Screen fully open in "A" to allow insertion of work; fully closed in "B" to permit operation to take place

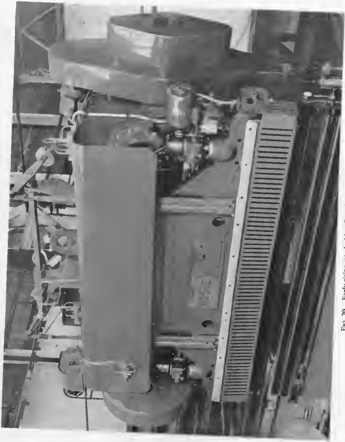

FIG. 20. Early-rising interlocking Guard Screen in raised position.

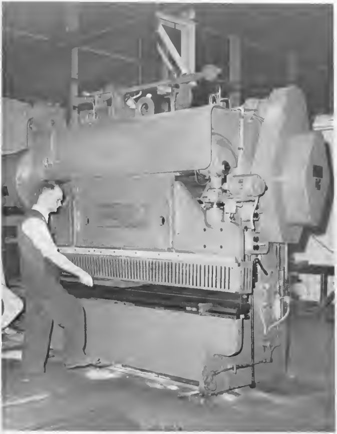

FIG. 21. Early-rising interlocking guard screen in down position.

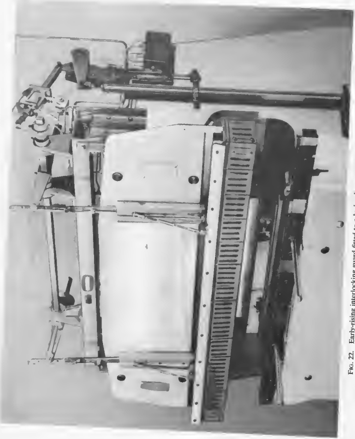

FIG. 22. Early-rising interlocking guard fitted to a hydraulic upstroking press brake screen raised.

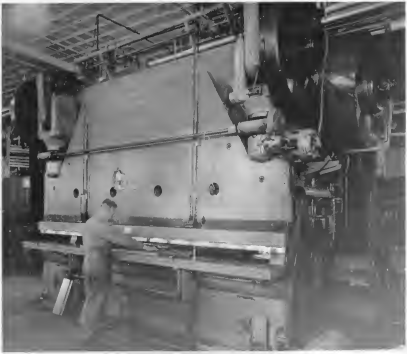

FIG. 23. Early-rising interlocking guard with edge detection on bottom of guard screen. (See paragraph 2.11).

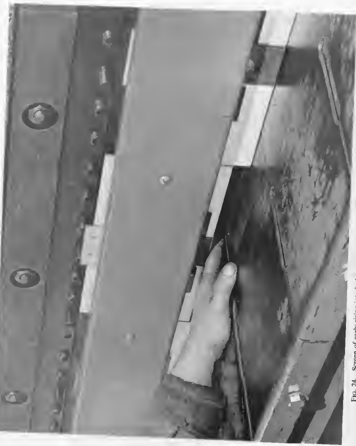

Fig. 24. Screen of early-rising interlocking guard with edge detection. (See Figs. 23 and 25). Machine will not operate with a person's fingers or similar obstruction under guards screen.

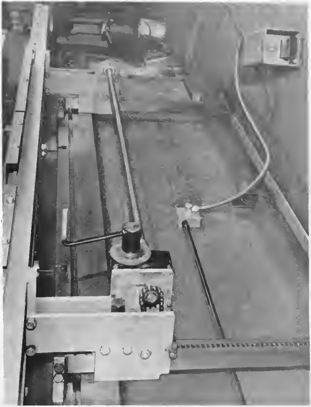

FIG. 25. Easily adjustable work-table used in conjunction with guard shown in Figs. 23 and 24. View of underside of table.

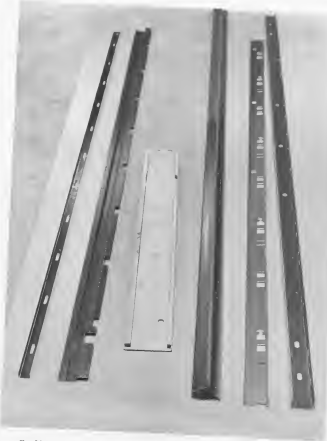

FIG. 26. Examples of work done on machine fitted with guard shown in Figs. 23, 24 and 25.

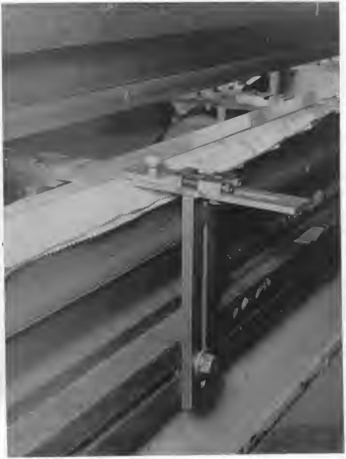

FIG. 27. Spring-loaded holding device for narrow work. Guarding removed for clarity.

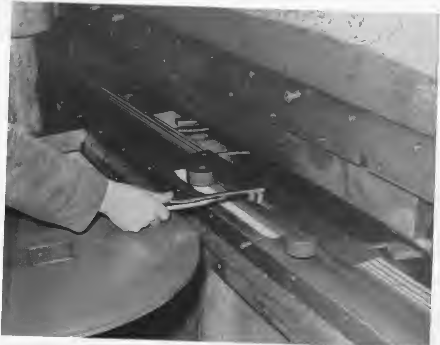

FIG. 28. Magnetic working-holding and work-handling devices. Guarding removed for clarity. The holding devices consist of permanent magnets whose top surfaces are placed level with the top of the bottom tool so as to hold the projecting workpiece. The work-handling device releases workpiece on operation of a lever on the handle.

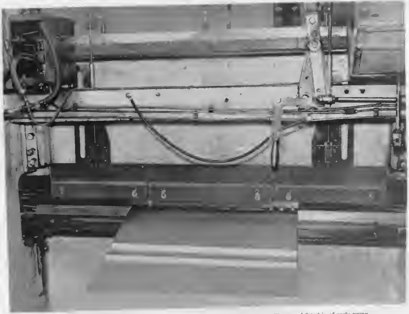

FIG. 29. Protection at back of machine provided for back feeding operation. The guard fitted is of early-rising interlocking type fitted with a back screen inter-connected to the front screen so that both move up and down.

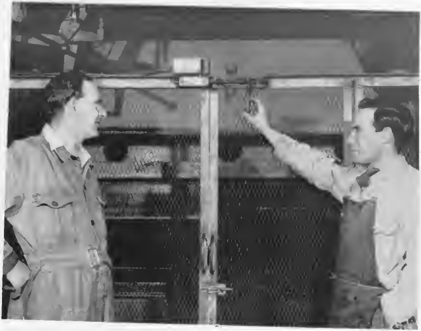

Fig. 30. Fencing at the back of a machine so arranged that drawing of the bolt causes disengagement of the clutch.

PART III: TOOL DESIGN

3.1 We consider that a major consideration in tool design should be to obviate the necessity for the operator's hand to be placed between the tools and therefore in jeopardy. This is particularly the case where narrow work is being done, as many types of guard permit access when the clutch is disengaged. There is ample scope in our opinion for the ingenious tool designer to provide some form of device for placing the workpiece in position, and it is strongly recommended that tool designers give attention to this point.

3.2 Some of the more common operations performed on press brakes are:

(*a*) 'V' bending, either single bends or multiple bends carried out in a progressive sequence.
(*b*) Channel forming.
(*c*) Off-set forming and doubling operations.
(*d*) Multiple piercing operations.
(*e*) Notching and trimming operations.

Many other operations are carried out in the normal course of work, but the multiplicity of operations which can be performed at a press brake create a much greater problem in the jobbing type of shop than in a high production shop where certain machines can be allocated to specific types of operation.

3.3 We find that because the types of operation vary so widely the types of tool employed also vary widely. We realise that jobbing shops will frequently have a different approach to a given problem than the high production shop. The former tend to make tools that are universal to a greater extent than the latter. Tools mainly employed are:

(*a*) 'V' bending tools – these are generally supplied with the machine and carry multiple impressions of varying width. The standard tools are usually made for the production of 90° bends.
(*b*) Channel forming tools – these can be of fixed size or may be made adjustable for width, and are usually fitted with a spring pressure-pad-type of ejector in the die (Figs. 32 and 33).
(*c*) Multiple piercing tools – these are usually of two types:
  (1) the rail-type of tool in which button dies and punches are set in line in a common die shoe and punch holder;
  (2) individual units (punching units) which are set individually along the bed of the machine.
(*d*) Planishing tools for hemming, round hemming or Dutch bending.
(*e*) Double 'V' or off-set tools. These are used in cases where two right-angle bends are close together or are so small that individual bending is impracticable. (See Fig. 34 for such tools used in conjunction with swinging back stop).
(*f*) Pittsburgh seaming tools.

There are also many other tools designed for specific jobs or products which fall into special categories.

3.4 We found that it is the general practice when using tools of type (*a*), i.e. 'V' tools, to work against fixed stops which are usually supplied as standard equipment with machines, and it is our opinion that some better arrangement could and should be designed. The type of stop arrangement visualised would be adjustable from the front of the machine (Fig. 35) and would be provided with a suitable locking medium for securing into position. This would eliminate the hazard of reaching through the machine to tighten or loosen the securing nuts. This type of back gauge could be built into the auxiliary die holder usually associated with press brakes for holding the 'V' dies. As such, it could conceivably become a universal back gauge for use with several types of tools.

3.5 Channel-forming tools are usually used in conjunction with medium to narrow work, and for positioning or locating the workpiece the arrangement of backstops mentioned above could be used as an alternative to "set edges" on the die itself. As this work is of generally narrow width a suitable slide arrangement could be designed if necessary for transferring the strip from a feed table or support to the correct position up against the back stops. The designing of such a piece of equipment, which could be of a universal nature, would enable fixed guards to be used. This arrangement could also be used when multiple piercing tools are used on narrow work, but if the work is of a reasonably wide nature the feeding arrangements could be dispensed with and the work fed into the tools through the opening of a fixed guard (Figs. 31 to 33). Spring, rubber or fixed strippers, whichever type is preferred, could be fitted to the tools (Figs. 32 and 33).

3.6 Planishing tools, particularly on narrow work which is folded and flattened, hemmed or Dutch bent, can be particularly dangerous and it is desirable that some form of feeding arrangement as outlined above be provided in conjunction with fixed guarding. The same remarks are true also of Pittsburgh seaming tools. It should also be possible to apply similar feeding arrangements and back gauge systems to the use of double 'V' and "off-set" tools. To facilitate the use of such safety features in the tool some form of lightly spring-loaded support fingers could be incorporated in the tool design.

3.7 To carry these aspects of safety in tool design to a logical conclusion, they must be considered in conjunction with the machine operating mechanism, together with the ejection of pieces from between the tools, more particularly when these piece parts are of narrow form. In this connection we visualise that a slide feed arrangement as already mentioned could be made adjustable through a fairly wide range to accept parts up to a width in which the operating does not entail danger, that is where the piece can be placed through the horizontal opening of a fixed guard. By use of a linkage gear the operating of the slide could be made to slide the interlocking bolt into the clutch-operating mechanism and at the same time open a section of the back guard to allow the piece to be ejected mechanically from between the tools.

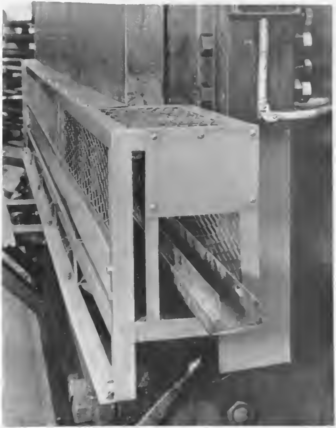

FIG. 31. Fixed guard. End view of guard showing how component is withdrawn through end opening in guard. The opening must be so placed as to prevent fingers from reaching the trapping area. An implement such as a rod can be used for freeing the component. (See also Fig. 32).

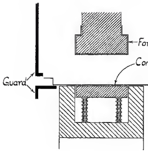

FIG. 32. Diagrammatic cross-section of guard shown in Fig. 31 showing relationship of guard, work and tools.

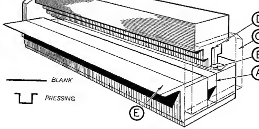

FIG. 33. Tool design. Example of methods adopted to free channelled component from punch and die so that it can be pushed clear of the tools by the next component. The die incorporates a spring-loaded pad A to eject the work to die level. Pin B (which is duplicated at the other end of the die set) mounted on end plate C (secured to the die), strips the work off the punch, so that it is free to be pushed to the rear. Slots D are cut in the punch to clear pins B. A plate E facilitates feeding of the components under the fixed guard which is arranged to give a feed opening ⅛ in. deep.

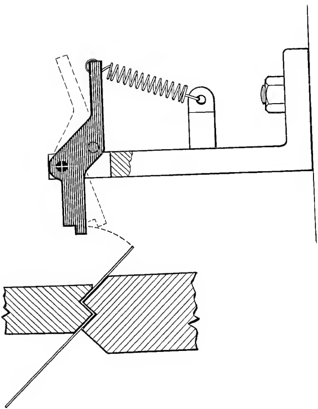

FIG. 34. A useful swinging back stop.

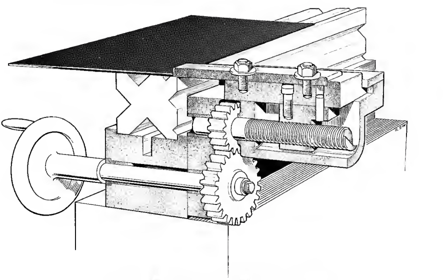

FIG. 35. A back stop which is adjusted by a hand wheel in the front of the machine.

PART IV: GENERAL

4.1 We consider it most important in the interests of safety that press brakes and their guards should be subject to planned inspection and thorough examination and maintenance. The most important single piece of equipment on a press brake is, perhaps, the brake. It is vital that it arrests the crank of the machine positively and at the right moment. We regard this as so important that we recommend it should be inspected and have its performance checked at least twice daily before being used, and after prolonged use. It is important that the clutch disengages promptly and completely, as clutch drag which can occur for various reasons can cause a repeat stroke. Apart from the clutch and brake themselves their control arrangements also need close attention. We do not consider it advisable in this Report to attempt to give itemised recommendations for inspection, thorough examination and maintenance as machines vary considerably in detail, but obviously the brake and clutch, including their control arrangements, should be thoroughly examined and maintained at regular intervals. Where clutches are of the enclosed type it is considered that they should be stripped for this examination, primarily because the presence of quantities of dust or debris from friction linings has been known to result in drag with consequent repeat stroking.

4.2 It is equally necessary that guards should be properly maintained and section 16 of the Factories Act 1961 places a statutory duty on the factory occupier in this respect. Examination and maintenance of a static fixed guard is a fairly simple matter; specialised knowledge is however required in the case of other types of guard and it is recommended that this examination and maintenance be carried out by a person with experience and knowledge in this field.

4.3 In our view care should be taken in the selection of workers to operate press brakes and all new operators should have explained to them:

- (*a*) The method of stopping and starting the machine.
- (*b*) The nature of the dangers known to arise in the course of ordinary working.
- (*c*) The dangers liable to arise from bad practices, from inattention and from misuse.
- (*d*) The function of each safety device or guard, together with the necessity for informing the management immediately of any faults or defects that have arisen and that the operator should under no circumstances attempt to correct the faults himself.

Instructions should be given that guards or safety devices are not to be removed or tampered with and that adjustable guards should only be readjusted by, or under the instruction of, a responsible person.

4.4 In the case of young persons, that is to say persons who have not reached their 18th birthday, section 21 of the Factories Act 1961 places a statutory duty on the factory occupier to see that a young person is not employed at a press brake unless he has been fully instructed as to the dangers arising in connection with it and the precautions to be observed, and

- (*a*) has received sufficient training in work at the machine; or
- (*b*) is under adequate supervision by a person who has a thorough knowledge and experience of the machine.

4.5 Accidents can occur to persons while changing or setting tools at press brakes, and we have no doubt that where these operations cannot be performed with the tools securely fenced, they should not be carried out unless the power to the machine is switched off and the flywheel is at rest. In our opinion the safest position to stop the machine for tool changing is at bottom centre; any necessary movement of the beam can be obtained by either barring the flywheel round by hand, or by using the beam height adjustment mechanism.

4.6 Tools for press brakes are invariably long and heavy and accidents can be a direct result of attempting to insert or remove such cumbersome tools solely by human effort. To overcome this hazard, certain mechanical handling equipment can be of use, such as:

(*a*) fork-lift trucks;

(*b*) portable cranes;

(*c*) hoists fitted over each machine;

(*d*) overhead cranes.

In order to facilitate the use of such equipment, provision should be made in the design of the tools by providing fitments for attaching slings, or arrangements for inserting the forks of fork-lift trucks (Fig. 36). For convenience in handling, it may be desirable to strap the top and bottom tools together (Fig. 37) so that they can be handled as a single unit; if this is the case, the top tool can be brought down to the bottom tool and the tools strapped together. The beam can then be raised to top dead centre at which point the power to the machine should be switched off. A fork-lift truck or other lifting device can then be used to remove the tools from the machine. The reverse procedure can be applied for setting tools in the machine.

4.7 Where a large amount of 'V' bending is done, tool changing can be made easier by the use of a standard punch holder with interchangeable nose-pieces (Fig. 38). The standard holder can remain in the machine almost permanently, the nose-pieces only being changed. As these nose-pieces will be of much smaller cross section than a whole tool they will be comparatively light in weight. Nose-pieces other than the simple 'V' form can also be fitted to such a standard holder.

4.8 In our opinion, it is most important that setters be instructed in the function of the essential parts of the machine mechanisms, with the importance of correctly adjusting the guard after each tool set-up and of reporting immediately any damage to or malfunction of any part of the guard. The danger of over-setting or uneven setting should also be stressed.

Note: Certain of the recommendations in Part IV are legal requirements in the case of mechanical press brakes. (The Power Presses Regulations 1965 – SI 1965, No. 1441). HMSO.

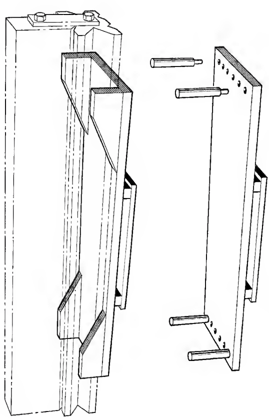

FIG. 36. Holders for facilitating the handling of heavy tools by fork-lift trucks.

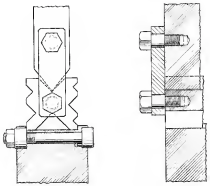

FIG. 37. These two views show how top and bottom tools can be clamped together to facilitate tool changing.

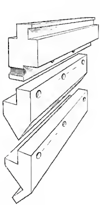

FIG. 38. Top tools showing how removable nose-pieces can be used.

Appendix I

Automatic Guard (This guard is illustrated in Fig. 10)

Principles of Construction

1. The guard embodies a mechanically-operated screen which extends across the full width of the machine.[1] The upper edge of the screen moves in an approximately horizontal direction below the plane occupied by sheet metal when it is placed in position for bending. Appropriate additional fencing should be provided to prevent access from any direction not protected by the screen.

2. The screen is constructed so as to prevent a person from standing in a position between the guard and the machine frame.

3. The guard is connected by suitable mechanical linkages to driving pins on the machine crankshaft and should be driven from both ends.

Performance

4. In its initial position the upper edge of the guard should not be less than 18 in. from the nearest part of the trapping area and when the nature of the operations permits, this distance should be greater than 18 in.

5. When the guard is actuated by forward rotation of the crankshaft, the upper edge should move forwards so that it attains a maximum outward position not less than 42 in. from the nearest part of the trapping area and at a height of not less than 42 in. from the standing position of the operator. These figures relate to an operator of average size.

This maximum outward position should be attained on the first one inch of down stroke, and thereafter the guard may commence its return movement so, however, that the upper edge of the guard shall be not less than 39 in. from the front edge of the trapping area until the space between "accessible" trapping surfaces (taking account of the workpiece as a surface) is ⅜ in. or less. The speed of the machine and the design of the guard should be such that at no time does the velocity of the upper edge of the guard exceed 6 feet per sec.

"Accessible" trapping surfaces, in this connection, means trapping surfaces which would be accessible in the absence of the guard.

6. When the clearance between "accessible" trapping surfaces has been reduced to ⅜ in. or less, the guard may return rapidly towards its initial position in order to allow the operator to retain control of the workpiece.

Machine Requirements

7. In order to secure the standard of performance specified in paragraph 5 it will generally be necessary so to mount the machine that the upper face of the bottom tool will be not less than 42 in. from the standing position of the operator.

8. The clutch controls will require modification so as to enable the operator to control the machine conveniently, taking into account the movement of the guard. Generally this will be limited to an extension of the pedal.

9. The guard should not be fitted to a machine having less than 2 in. daylight.

10. Where the design of the guard is not such as to give correct movement of guard in either direction of crankshaft rotation, means should be provided on the machine to prevent gravity fall-back of the slide.

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[1] When a screen of the same type is provided at the back of the machine as well as at the front the same standards for construction and performance, as specified here, should apply.

Appendix II

Interlocking Guards[1] (Examples of this type of guard are illustrated in Figs. 15 to 18)

Principles of Construction

1. An interlocking guard consists of an enclosure around the tools with a moveable screen interlocked with the brake and clutch in such a manner as to ensure that (i) except when the guard screen is closed, the brake cannot be released and the clutch cannot be engaged, and (ii) when the brake is released and the clutch engaged the guard screen cannot be opened.

Performance

2. The functions of the guard should be attained by means of suitable interlocking arrangements between the guard screen and the clutch and brake operating mechanism applied at a point as near as possible to the clutch and brake.

3. The guard screen may take the form in which, when closed, it is sufficiently close to the surface of the bottom tool or extension thereof, to prevent a person reaching into the trapping area. Alternatively, the screen may, when in the closed position, entirely enclose the front of the tools. This form would be appropriate where workpieces do not have to be supported by hand during the bending operation.

Machine Requirements

4. The normal (free) position of the clutch and brake mechanism should be clutch disengaged and brake fully applied, this position being maintained by springs or other effective means so disposed as not be affected by accidental disconnection of any part of the clutch operating mechanism.

5. Effective positive means should be provided for preventing non-powered overrun past top dead centre to such an extent that trapping between the tools can occur[2].

6. The brake should be so constructed and adjusted as to be capable of preventing gravity descent of the beam from any position of the crankshaft.

7. An effective single-stroke device should be provided which will ensure that the crankshaft comes to rest at or adjacent to top dead centre after each stroke.

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[1] This specification is for guards applied to mechanical press brakes. For hydraulic machines an equivalent standard should be adopted. (See paragraph 2.16 of this Report).

[2] Within five years from first publication of this Report arrestor devices should, however, be fitted which are capable of stopping crankshaft movement before danger can arise from the tools: (*a*) in the event of an uncovenanted stroke, including a repeat stroke, however caused, and (*b*) when the operative part of the guard permits access to the tool area during the dangerous part of crankshaft rotation. (See paragraphs 5 and 6 of the letter of presentation to the Minister, page 1 of this Report).

Appendix III

Early-Rising Interlocking Guard[1] (Examples of this type of guard are illustrated in Figs. 20 to 25)

Principles of Construction

1. The guard consists:

- (*a*) of a moving screen which extends for the full length of the tool bed of the machine and which, in its lowest position, will prevent access to the trapping area from the front of the machine; and
- (*b*) of appropriate additional fencing which will prevent access from any direction other than from the front.

When the back fencing is of the same moving screen type as that for the front, the requirements for the front screen are equally applicable to those for the screen at the back. (See Fig. 29).

2. The screen is so arranged that it rises as the work is bent in order that the workpiece shall not foul the screen.

3. The screen is raised by mechanical, hydraulic, pneumatic or electrical means, or by a combination of these means.

Performance

4. It should not be possible to engage the clutch until the screen is at its lowest level, at which level access to the trapping area must be effectively prevented.

5. When at its lowest level the screen should be locked or held in that position by suitable means until the gap between the descending tool and workpiece is so small that there is no risk of trapping, at which point the screen can be allowed to rise.

6. It should not be possible for the guard screen to trap or injure a person's fingers or hands. If necessary, the descent of the guard screen must be so moderated as to eliminate this possibility.

7. All guard interlocking arrangements should be so arranged that as far as is practicable, failure of any part results in safe conditions.

Machine Requirements

8. Effective positive means should be provided for preventing non-powered overrun past top dead centre to such an extent that trapping between the tools can occur[2].

9. The brake should be so constructed and adjusted as to be capable of preventing gravity descent of the beam from any position of the crankshaft.

10. An effective single-stroke device should be provided which will ensure that the crankshaft comes to rest at or adjacent to top dead centre after each stroke.

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[1] This specification is for guards applied to mechanical press brakes. For hydraulic machines an equivalent standard should be adopted. (See paragraph 2.16 of this Report).

[2] Within five years from first publication of this Report arrestor devices should, however, be fitted which are capable of stopping crankshaft movement before danger can arise from the tools (*a*) in the event of an uncovenanted stroke, including a repeat stroke, however caused, and (*b*) when the operative part of the guard permits access to the tool area during the dangerous part of crankshaft rotation. (See paragraphs 5 and 6 of the letter of presentation to the Minister, page 1 of this Report).

Appendix IV

Distance Bar Trip Guard (This guard is illustrated in Fig. 11)

Principles of Construction

1. A screen is mounted in such a manner and so connected to the clutch control mechanism as to require that it must be pulled out from the machine to a specified distance from the trapping area before the clutch can be engaged. If the screen is moved towards the trapping area, the initial part of such movement disengages the clutch and applies the brake. Appropriate additional fencing should be provided to prevent access from any direction not protected by the screen.

2. This device can conveniently be applied to a hydraulically-powered press brake or to a mechanically driven machine having any type of fluid control of the clutch as for example a machine with air-operated clutch. The principle can also be applied to a machine with a mechanically-operated clutch by incorporating a pneumatic link associated with guard movement between the operator's control and the clutch.

3. In the case of machines with electro-pneumatic control, the guard screen should control a valve in the air supply pipe to the clutch between the clutch cylinder and the main operating valve, also a limit switch in the electric control circuit. The limit switch should be positively controlled so as to prevent it from sticking in the closed or operative position.

Standard of Performance

4. The position of the screen when the machine may be operated should be such as to prevent the outstretched finger tips of a person from reaching to a point nearer than 9 in. from the front of the trapping area.

5. The screen, and its suspension arrangements, should be sufficiently sensitive to ensure that it will move freely when pressure is exerted on it as for example by a person attempting to reach, either inadvertently or with intent, towards the trapping area.

Machine Requirements

6. The clutch and brake system should be so constructed and maintained as to ensure that when the guard screen is moved towards the machine at a time when the beam is in motion, the beam will be brought to rest before an operator's fingers can reach the trapping area.

7. The brake should be so constructed and adjusted as to be capable of preventing gravity descent of the beam from any position of the crankshaft.

8. Effective positive means should be provided for preventing non-powered overrun past top dead centre to such an extent that trapping between the tools can occur[1].

9. An effective single-stroke device should be provided which will ensure that the crankshaft comes to rest at or adjacent to top dead centre after each stroke.

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[1] Within five years from first publication of this Report arrestor devices should, however, be fitted which are capable of stopping crankshaft movement before danger can arise from the tools: (*a*) in the event of an uncovenanted stroke, including a repeat stroke, however caused, and (*b*) when the operative part of the guard permits access to the tool area during the dangerous part of crankshaft rotation. (See paragraphs 5 and 6 of the letter of presentation to the Minister, page 1 of this Report).

Appendix V

Photo-Electric Safety Device[1] (Illustrations of this type of device are given in Figs. 12, 13 and 14)

1. *General Standard of Performance*

A safety device based on the employment of a photo-electric system must comply with the following standard:

(*a*) As long as any part of any person is within the space between the trapping surfaces of the tools, it must not be possible for the slide to be brought into motion by release of the brake and/or engagement of the clutch; and

(*b*) in the event of any interruption of the light barrier of the device by any person while the beam is descending, the beam must be brought to rest before any part of a person can be within the space between the tools, and it should not be possible for the beam to be set in motion again until the safety device has been completely restored to its normal condition and the clutch control mechanism has been restored to the clutch disengaged position; and

(*c*) the device, when completely assembled and in correct working condition must not be so affected by stray light (direct or reflected) whether artificial, natural or deliberately applied, as to cause danger.

2. *Detailed Requirements*

(*a*) Access to the tools from any direction not protected by the light curtain(s) should be prevented by efficient fixed guards or screens.

(*b*) The time of response of the device and the position of the light curtain should be such that no part of a person can be between the trapping surfaces of the tools before they have been brought to rest.

Note: The overall time from the interruption of the light curtain until the closing or opening of the circuit controlling the clutch is of the order of 0·02 seconds. In those cases where an intermediate contactor is used, the opening time of this contactor will be additional.

(*c*) The sensitivity should be such that operation results from the insertion of a standard template of a diameter determined in accordance with the following table:

Diameter of Template	*Distance of plane of light curtain from front edge of trapping area*
1½ in.	18 in.
2 in.	24 in.

The sensitivity shall not be capable of such adjustment as to render the apparatus ineffective as a safety device.

Additional arrangements should be made, e.g. by the provision of fixed fencing or by a photo-electric beam suitably positioned, to prevent a person from standing between the light curtain and the trapping area.

(*d*) The safety device should fail to safety in all possible respects and in any case in respect of failure of the source of light and failure of the electricity mains supply from any cause.

(*e*) The photo-electric device should be mounted in closest proximity to the remainder of the electronic apparatus and associated relay or relays.

(*f*) The electronic and electrical apparatus should be so mounted as not to be adversely affected by vibration or shock from the machine protected or from any other cause.

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[1] This specification is for guards applied to mechanical press brakes. For hydraulic machines an equivalent standard should be adopted. (See paragraph 2.16 of this Report).

(*g*) The electronic apparatus and the electrical equipment actuated thereby should be so enclosed as may be necessary to prevent failure resulting from dust, oil, moisture or corrosion. Particular attention should be given to the effective exclusion and/or removal of dust and other foreign matter when enclosures are opened for maintenance or other purposes.

(*h*) The insulation resistance of the high impedance input circuits of electronic equipment should not be less than 100 megohms measured at not less than 500 volts.

(*j*) The electronic apparatus should be closed and locked and the key should be accessible only to an authorised person. The expression "authorised person" means the occupier of the factory or such other person appointed by him to be responsible for the proper operation of the apparatus.

(*k*) There should be incorporated in the equipment an automatic check of the electronic apparatus operating at each cycle of the machine whereby failure will prevent any further movement of the slide. (Also see paragraph 2 (*c*) which contains recommendations as to sensitivity).

(*l*) A check should be devised to prove at any time that the speed of response of the whole apparatus secures a standard in accordance with the General Standard of Performance and the requirements of paragraph 2(*b*) and 2 (*c*).

(*m*) The operation of the device should not be affected by normal variations of supply voltage and frequency.

(*n*) The mechanical, electrical and electronic parts of the whole equipment should be periodically inspected and efficiently maintained by a person or persons competent for the work and records should be kept.

3. *General Notes*

(*a*) When special risks such as flammable surroundings may obtain, appropriate safeguards, in addition to those specified in this memorandum, may be necessary.

(*b*) A check as defined in paragraph 2 (*l*) should be made at the commencement of each shift, once thereafter in each shift and before each fresh production run after setting of the tools.

(*c*) Each operator and setter should receive such instructions as will enable him to understand the function of the device sufficiently for him to be able to recognise defects in operation.

4. *Machine Requirements*

(*a*) Effective positive means should be provided for preventing non-powered overrun to such an extent that trapping between the tools can occur[1].

(*b*) The brake should be so constructed and adjusted as to be capable of preventing gravity descent of the beam from any position of the crankshaft.

(*c*) An effective single-stroke device should be provided which will ensure that the crankshaft comes to rest at or adjacent to top dead centre after each stroke.

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[1] Within five years from first publication of this Report arrestor devices should, however, be fitted which are capable of stopping crankshaft movement before danger can arise from the tool (*a*) in the event of an uncovenanted stroke, including a repeat stroke, however caused, and (*b*) when the operative part of the safety device permits access to the tool area during the dangerous part of crankshaft rotation. (See paragraphs 5 and 6 of the letter of presentation to the Minister, page 1 of this Report).

Appendix VI

Fixed Guards (Examples of fixed guards are illustrated in Figs. 4 to 8, 31 and 32)

Principles of Construction

1. A fixed guard consists of an enclosure for the tools which prevents access of fingers to the trapping area from any direction.

2. In order to facilitate removal of the workpiece the use of fixed guards can be extended by permitting a limited movement of the front screen. This type of guard has been referred to in this Report as a hanging screen fixed guard.

3. The hanging screen fixed guard consists of a screen at the front of the machine which extends the full length of the tool bed. This screen hangs on hinges or on trunnion-type fixings and has a limited amount of free movement on such hinges or on trunnions so as to permit the screen to closely approach the front of the top tool for bending to take place outside the screen. It also allows the screen to move away from the tools for removal of the workpiece.

Performance of Hanging Screen Fixed Guard

4. The movement of the screen in conjunction with the height of the screen above the surface of the bottom tool, or any extension in the form of a work-table that may be necessary to the bottom tool, should be so restricted in each direction as to prevent access by a person's hand or fingers to the trapping area.

5. Where variations in height of bottom tools are likely to be encountered it is essential that facilities for vertical adjustment of the screen should be provided.

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